REPORT ON THREE AEROMAGNETIC ANOMALIES:

SOUTHEAST OF MONCTON, NEW BRUNSWICK

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REPORT ON THREE AEROMAGNETIC ANOMALIES: SOUTHEAST OF MONCTON, NEW BRUNSWICK

Minerals and Energy Division

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ABSTRACT

Three closed magnetic highs, 5 km southeast of Moncton, are shown on the Geological Survey of Canada aeromagnetic maps of the region. Qualitative interpretation and maximum depth estimates indicate that these anomalies are associated with small erosional remnants on the basement surface of the Westmorland Uplift. Attempts to model the anomalies as rectangular prisms were not successful, probably because of the inhomogenous distribution of magnetic minerals in the source rocks.

RÉSUMÉ

Trois crêtes magnétiques fermées, situées à 5 km au sud-est de Moncton, sont indiquées sur les cartes magnétiques levées par avion de la région, réalisées par la Commission géologique du Canada. Une interprétation qualitative et des estimations de la profondeur maximale indiquent que ces anomalies sont associées à des résidus d'érosion de petite taille sur la surface du soubassement du soulèvement de Westmorland. Des tentatives visant à représenter ces anomalies par des prismes rectangulaires sont demeurées sans succès, probablement à cause de la distribution hétérogène des minéraux magnétiques de la roche-mère.

INTRODUCTION

Three closed magnetic highs of between 600 to 700 gammas were mapped by the Geological Survey of Canada in an aeromagnetic survey flown in the Moncton-Hillsborough area during May, 1958. The anomalies cover approximately 30 square miles, between latitudes 45° 59' and 46° 05' N and longitudes 64° 42' and 64° 46' W, southeast of the city of Moncton (Geological Survey of Canada 1960a, b). Flight altitude was 1000 feet and a line spacing of roughly 1/2 mile was maintained. The magnetic declination in the area during 1958 was 23° 34' West and the magnetic inclination was approximately 75°.

The survey area is part of a flat plain; the relief rarely exceeding 200 feet. Most of the relief is associated with the valleys of the Petitcodiac River and Mill Creek. A thin cover of glacial drift lies on top of flat-lying Pennsylvanian bedrock. The bedrock surface generally reflects the surface topography, with bedrock lows underlying the river and stream valleys (Hobson and Carr 1967). In two boreholes, BH 5 and BH 6 (Figure 1), a basement complex of granite and chlorite schist was intersected at depths of 350 and 355 feet respectively (Carr 1968). Four additional holes (BH 7 to 10), drilled after submission of this report, also intersected basement (see Addendum, p. 13). The borehole logs are provided in Appendix I.

In the descriptive notes accompanying Geological Map 646A, Moncton Sheet, Norman (1941) states that the basement complex

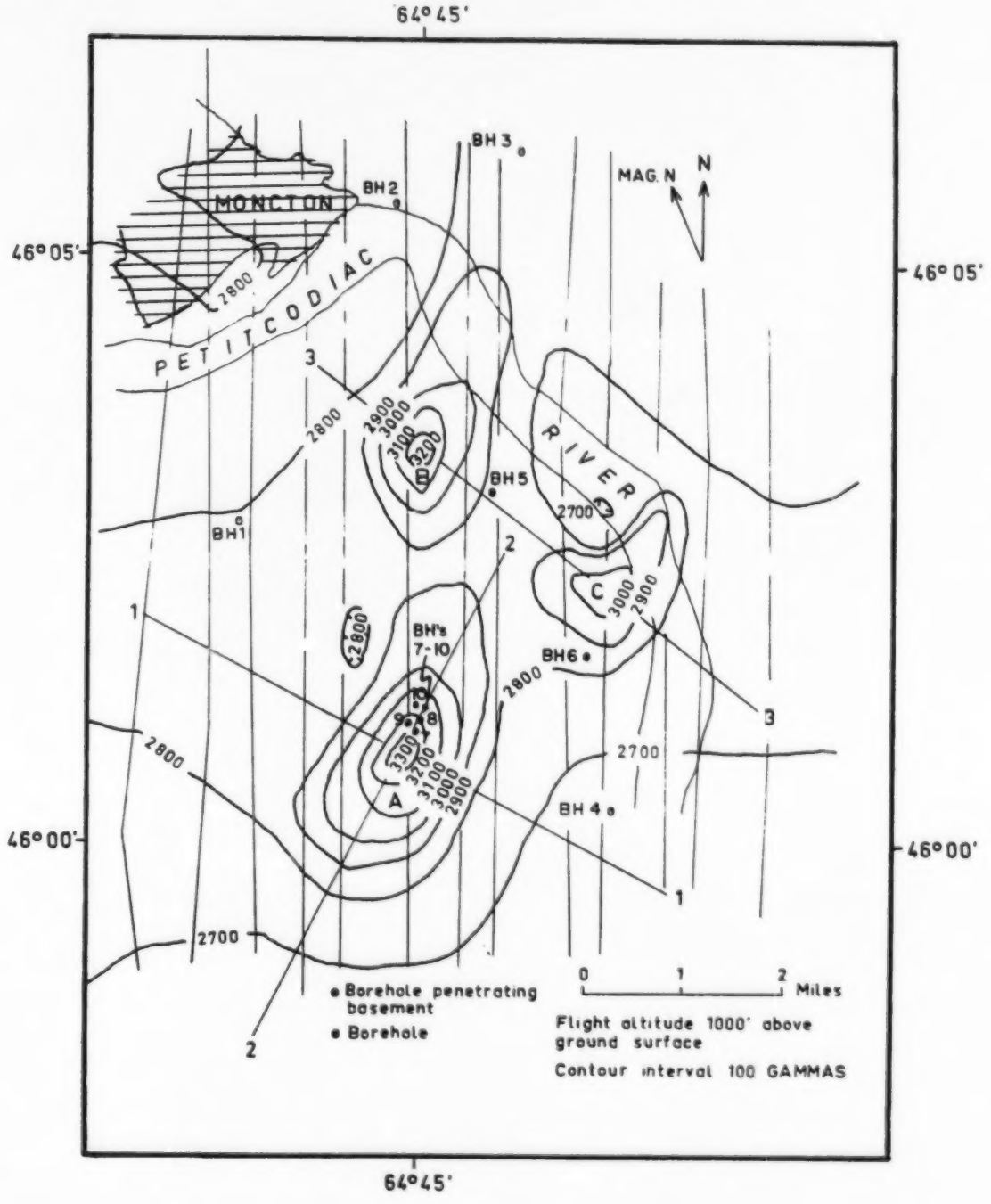

FIGURE 1. Aeromagnetic anomalies southeast of Moncton.

includes masses of titaniferous magnetite and ilmenite. He also mentions that the pre-Carboniferous rocks probably form a buried ridge that extends eastward to include similar pre-Carboniferous rocks exposed on the Memramcook River. Gussow (1953), on the basis of the same drilling information and additional gravity and seismic data, also concluded that a pre-Carboniferous basement high exists between Moncton and the Stoney Creek oilfield to the south. Similar highs were discovered to the east by seismic reflection surveys and drilling and Gussow interprets the area to be underlain by the Westmorland Uplift, a pre-Carboniferous buried ridge extending for more than 20 miles in a northeasterly direction. It is interesting to note that local highs of 2 to 3 milligals on Gussow's gravity map (Figure 13, op. cit.) occur in the same region as the aeromagnetic highs.

The purpose of this report is to examine the nature of the aeromagnetic anomalies and give a detailed interpretation. Recommendations for further work in the area will be suggested.

INTERPRETATION OF AEROMAGNETIC ANOMALIES

The main features of the aeromagnetic anomalies are shown in Figure 1, which is a contour plot of the magnetic field values at 100 gamma intervals. A more detailed contour plot at 10 gamma intervals is available on Geophysics papers 803 and 809, and these maps were used in the construction of all

profiles and later interpretation. The anomalies have been labelled 'A', 'B', and 'C' for convenience of reference.

All three anomalies are closed magnetic highs, flanked by small magnetic lows to the northwest. If the source of the anomalies is simply a concentration of magnetic material in the basement complex, an appropriate interpretation model would be a prismatic cell (bottomless, vertical-sided prism of rectangular cross section) with a magnetic strike of 45°E of magnetic north, in a geomagnetic field with an inclination of 75° (Vacquier et al. 1951, Figure A75). This model was selected for the first attempt at interpretation and two profiles 1-1 and 2-2 were drawn across anomaly A, the latter being the best-resolved anomaly of the three. These profiles are plotted in Figure 2.

The shape of the anomaly profiles over the prism model is controlled by five quantities;

a) the length of the two sides (a and b)

b) the depth (h) below the magnetometer

c) the magnetic azimuth (λ) of side b

d) the magnetic dip or inclination (i)

If a is chosen as the unit of measurement, the number of parameters can be reduced to four; $\frac{h}{a}$, $\frac{b}{a}$, λ, and i. If the last two parameters are known or assumed, certain characteristic features of the anomaly profiles can be used to eliminate a and b and so determine h in a method described by Grant et al. 1965.

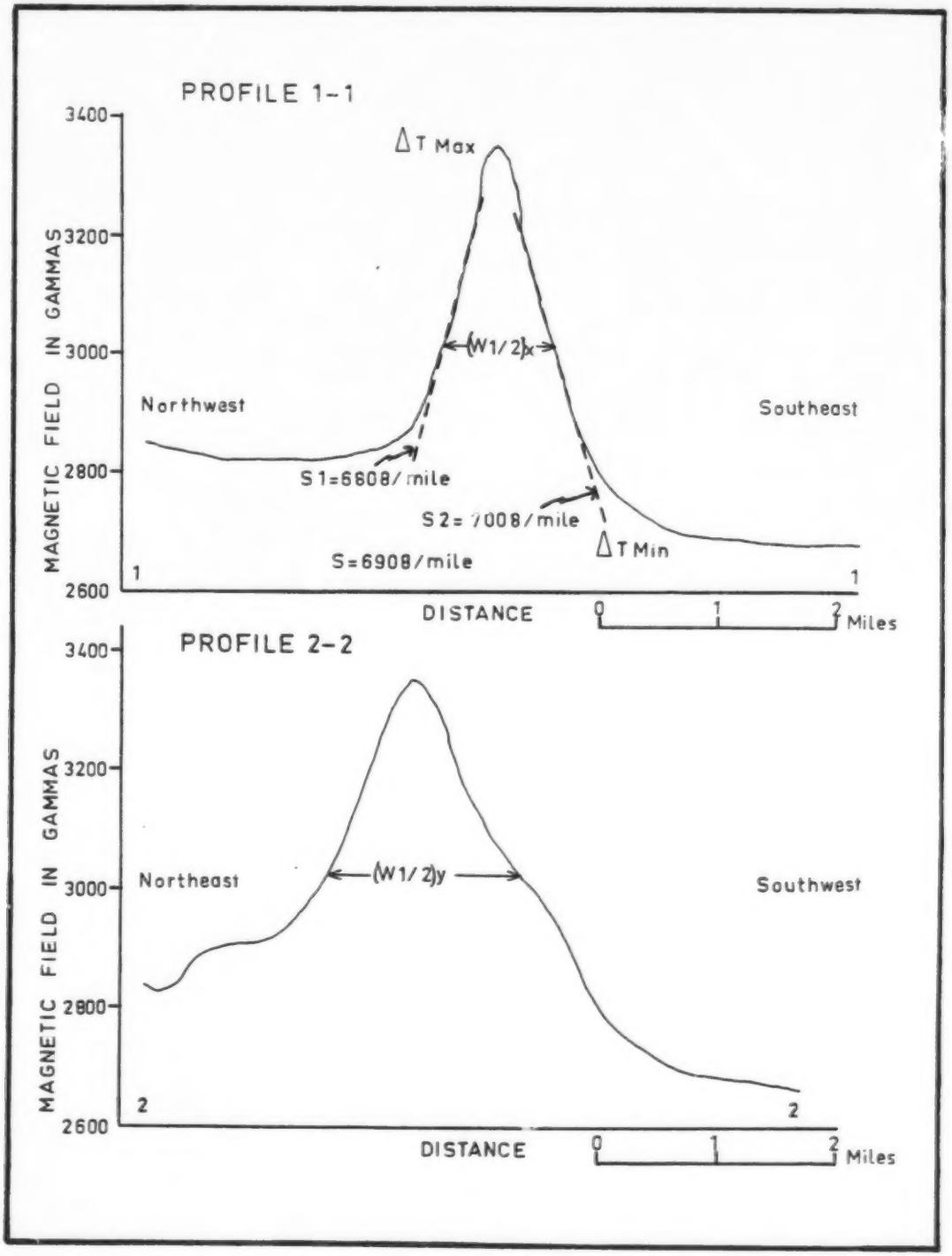

FIGURE 2. Profiles 1-1 and 2-2 across anomaly A.

The ratio of the two half widths of the anomaly $(W\frac{1}{2})x$ and $(W\frac{1}{2})y$, parallel to and transverse to its 'strike' direction is a good estimator for the ratio $\frac{b}{a}$ (see Figure 3). In magnetically high latitudes ($|i| \geqslant 60°$), a good estimator for $\frac{h}{a}$ is the ratio of the product of $(W\frac{1}{2})x$ and the mean maximum horizontal gradient ($\bar{s}$) to the total amplitude of the anomaly (ΔT max - ΔT min), Figure 3.

Sets of characteristic curves for these estimators as a function of magnetic azimuth (λ) and magnetic inclination (i) have been prepared and the characteristic curves for i = 75° and λ = 45° are shown in Grant et al. 1965, Figure 11.23. Once $\frac{b}{a}$ has been estimated, a second chart with the ratio $\frac{h}{a}$ plotted as a function of $\frac{(W1/2)x}{h}$ for various values of $\frac{b}{a}$ can be used to determine h (Figure 11.24, op. cit.).

The magnetic inclination in the survey area is about 75° and the magnetic azimuth of the anomalies is between 40° and 45°, so that the charts in Grant et al. 1965 can be used directly for interpretation.

ANOMALY A

$(W\frac{1}{2})x$ = 0.95 miles

$(W\frac{1}{2})y$ = 1.65 miles

$\frac{(W1/2)y}{(W1/2)x}$ = 1.74

$\bar{s}$ = 690 gammas/mile

$$\Delta T \text{ max} - \Delta T \text{ min} = 670 \text{ gammas}$$

$$\frac{\bar{s}\ (W1/2)\ x}{\Delta T \text{ max} - \Delta T \text{ min}} = \frac{690 \times 0.95}{670} = 0.98$$

This latter factor falls below the abscissa of the characteristic curve chart, which means that the prism is not a suitable model and the anomaly is probably associated with some relief on the basement surface.

Attempts to fit simple models, such as depth-limited prisms and tabular blocks, to this anomaly also resulted in failure. Closer inspection of the profiles suggests that the actual anomaly is too complex to be explained by a simple model. For instance, the horizontal gradient increases in the vicinity of the peak. Therefore, the probable cause of the anomaly is likely to be an irregular distribution of magnetic material. The maximum depth of this material can be estimated by considering the most concentrated form that the material can take, a point pole. Henderson and Zeitz (1948) and Smellie (1956) have suggested methods of determining depths to point poles and line poles by measuring half maximum anomaly distances on anomaly profiles and then using these distances in an equation such as: Depth = coefficient x half maximum anomaly distance, where the coefficient is a function of the magnetic inclination and direction of the profile. Using the method proposed by Smellie, the half maximum anomaly distances on a profile along the magnetic meridian through anomaly A were measured.

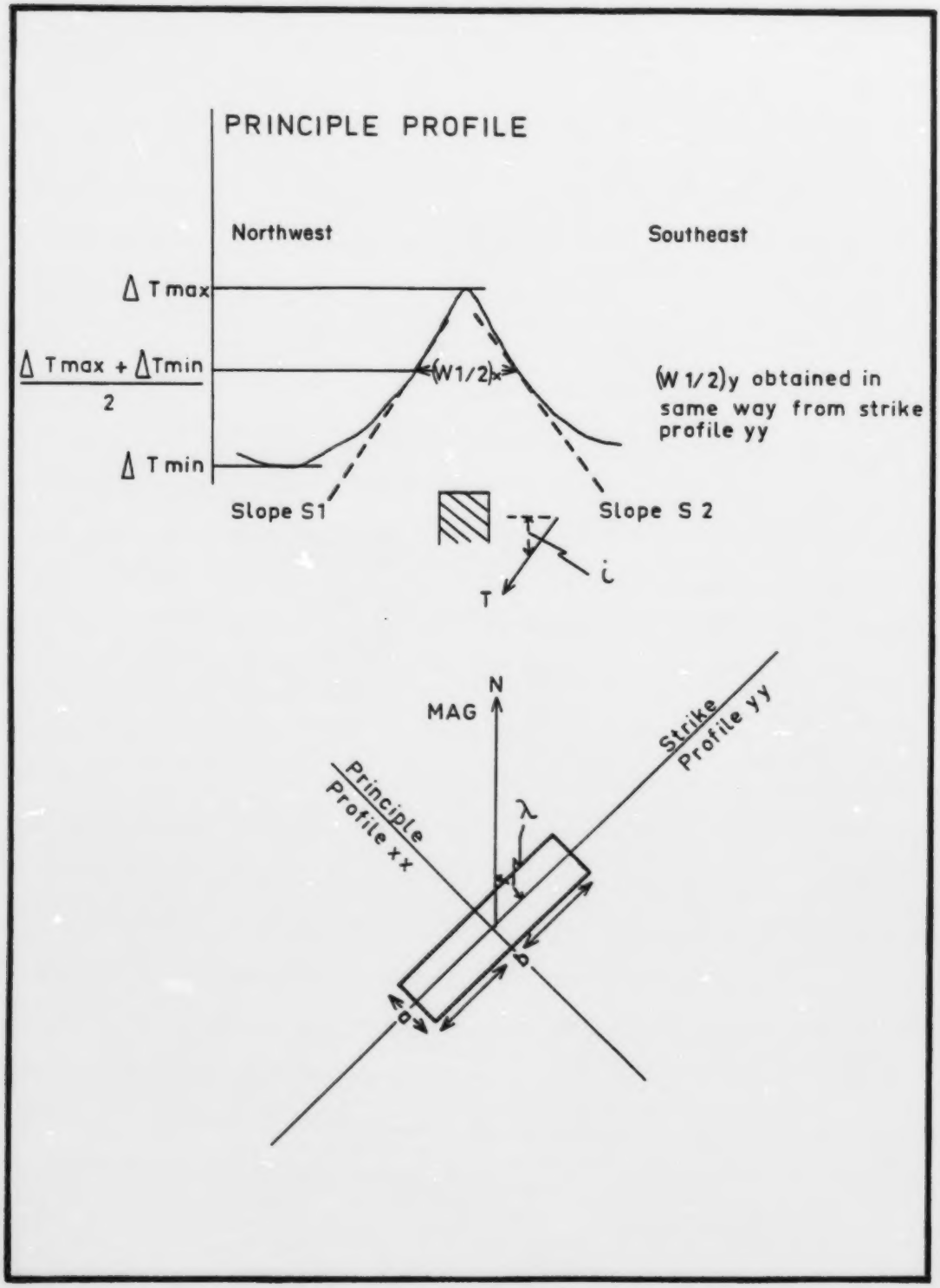

FIGURE 3. Anomaly parameters for prism model.

North side of profile

Depth = 1.4 x 0.45 = 0.63 miles

South side of profile

Depth = 1.2 x 0.65 = 0.78 miles

Average depth = 0.70 miles

Depth of point source below ground surface

= 3700 - 1000 = 2700 feet

The top of the magnetic material that causes the anomaly, therefore, is less than 2700 feet below ground level and because the material must be distributed through an extended volume, the source is likely to be much closer to the surface.

ANOMALY B

Attempts to fit simple models to this anomaly were also unsuccessful. The depth to a point pole using Smellie's method, is 0.65 miles or 3420 - 1000 = 2420 feet below ground surface, and represents a maximum depth for the magnetic source.

ANOMALY C

Anomaly C is smaller than A and B and complicated by interference from the eastern flank of anomaly B (Figure 4). Again no simple model could explain the anomaly. Using

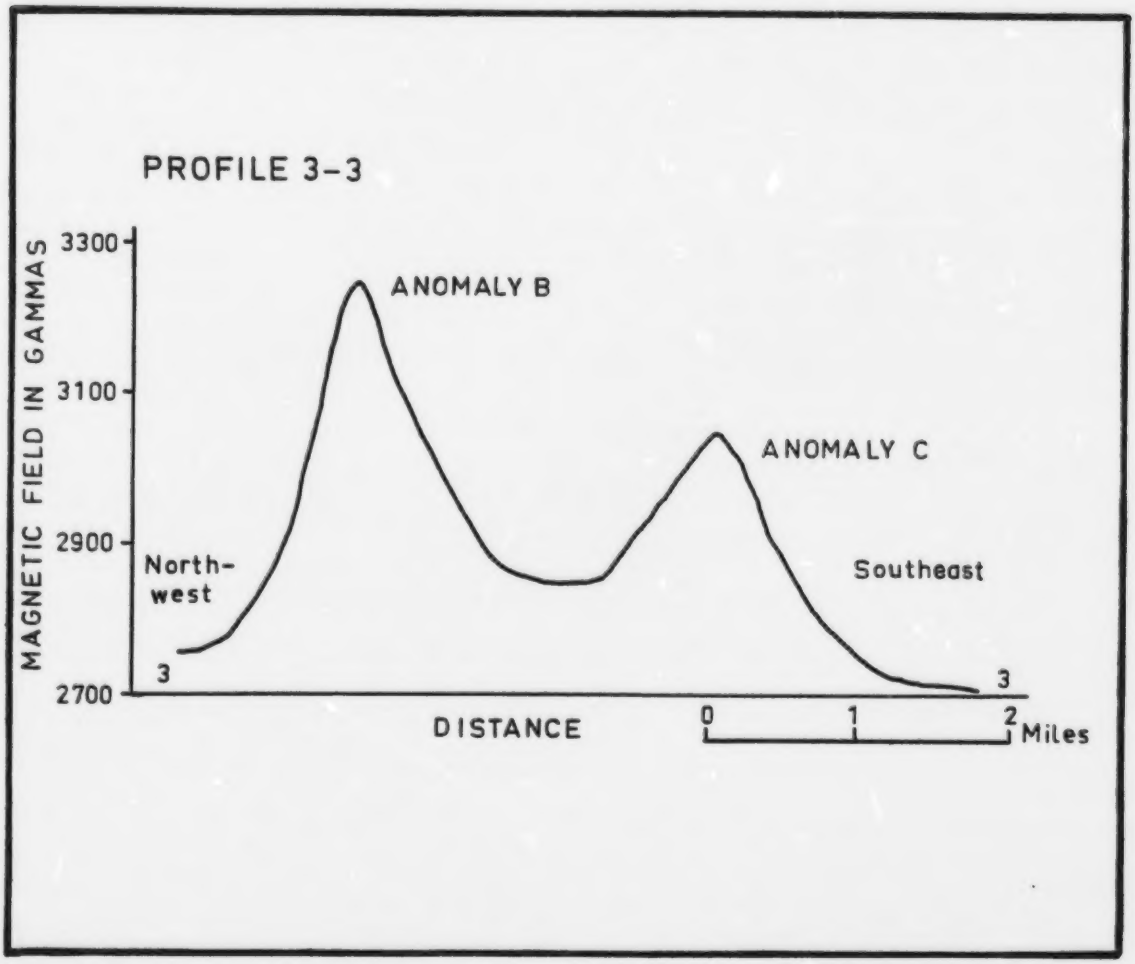

FIGURE 4. Profile 3-3 across anomalies B and C.

Smellie's method, the depth to a point pole for this anomaly is 0.48 miles or 2540 - 1000 = 1540 feet below ground surface, and represents a maximum depth for a magnetic source.

It is difficult to obtain quantitative information from the magnetic anomalies. However, if we restrict ourselves to a qualitative type of interpretation, plausible geological features that might explain the localized magnetic highs are small erosional remnants on the basement surface forming the

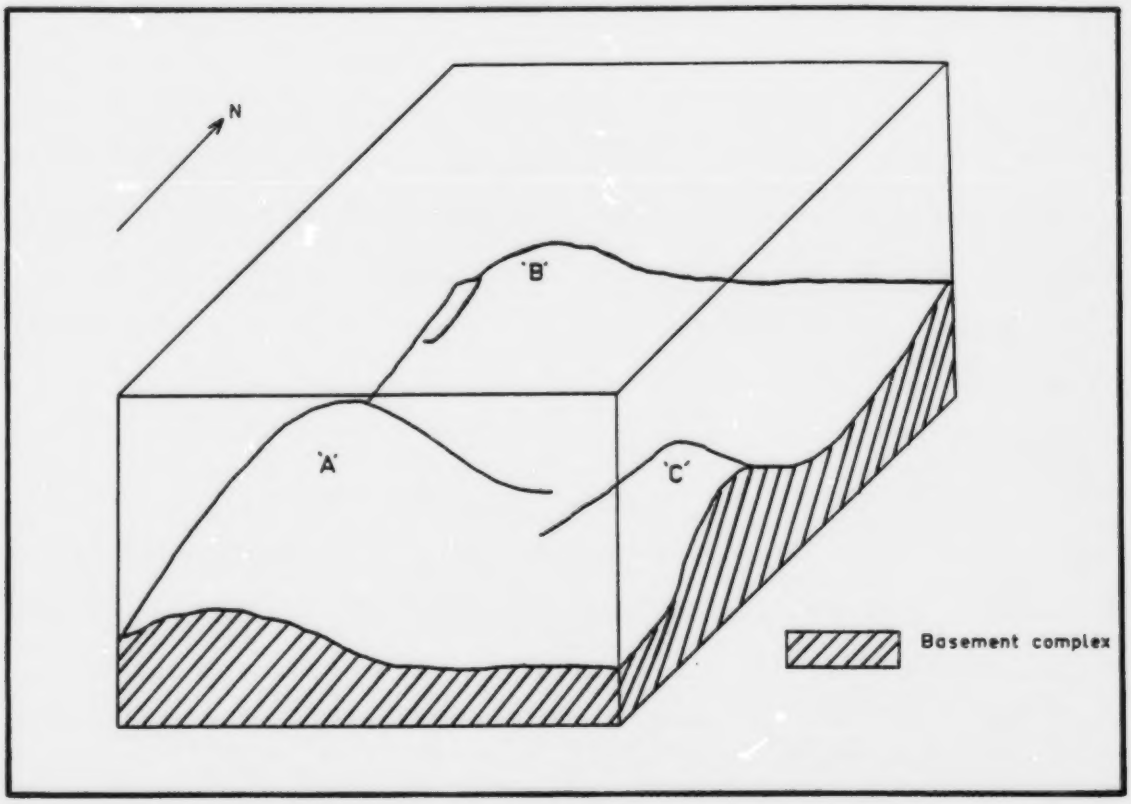

FIGURE 5. Schematic view of basement surface.

Westmorland Uplift (Figure 5). It cannot be deduced from the magnetic survey alone whether the source of magnetization in the buried remnants is mineralization of economic interest. In addition to the uncertainty with regard to the shape of the magnetic body, there is no information on the relative contribution of remnant and induced magnetization, which is necessary if the percentage of magnetite is to be estimated from the magnetic anomalies.

RECOMMENDATIONS

1) An attempt should be made to obtain more definitive information on the mineralization present in the chippings from boreholes (BH 5 and BH 6). An examination of rocks of the same type, occurring in outcrop in the Caledonia Mountain region might yield useful information, particularly as some units are associated with magnetic highs of the same order of magnitude.

2) If the study of the chippings proves encouraging, further geophysical work might be of assistance in delineating the boundaries of the mineralization. A detailed gravity and ground magnetic survey would provide a more precise location of the anomalies. On an experimental basis, an induced polarization or a VLF electromagnetic survey would indicate the presence of conductive mineralization, although the relatively great depth of the mineralization might be a limiting factor.

3) If significant mineralization is indicated, it is recommended that a borehole be drilled at one of the following locations and the mineralized zone cored.

a) Location I, about $1\frac{1}{2}$ miles south of Gunningsville on Highway 114.

b) Location II, about $\frac{1}{2}$ mile to the east along side road off Highway 114, 1 mile south of Mud Creek.

c) Location III, $\frac{3}{4}$ mile northeast of Crossman along NE fork of side road from Highway 112.

The specific location of the drilling site should be decided after considering the logistics problem in each area.

4) If adequate amounts of mineralization are proven, a more comprehensive drilling program should be planned to completely evaluate the deposit. From a study of the physical properties of the core samples, a detailed interpretation of the geophysical results should be possible.

ADDENDUM

After the interpretation described in this report had been completed, four boreholes were drilled in anomaly A by Killarney Oil and Gas Co. Ltd. as part of a titanium exploration program (BH 7 to 10; Figure 1). An anorthositic gabbro was encountered at depths varying between 388 and 408 feet below the surface, well within the maximum depth of 2420 feet below ground surface predicted by the magnetic interpretation of anomaly A. The gabbroic samples obtained from the boreholes contained what was identified as "magnetic minerals, either ilmenite or magnetite, or both", the higher concentrations being contained within the coarser anorthositic sections. A summary of the drill logs for these four additional boreholes is found in Appendix I of the present report. More detailed information may be found in the Killarney Oil and Gas Co. Ltd. assessment report (Kemp 1971).

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APPENDIX I

GEOLOGICAL LOGS OF BOREHOLES IN AREA
(adapted from Appendix A, Carr 1967)

BOREHOLE NO. 1

DRILLED BY: Geological Survey of Canada YEAR: 1961

LOCATION: 46°02'55" N ; 64°47'20" W

ELEVATION: 108 ft. (a.s.l.)

Group/Formation	Depth Interval (ft.)	Description
Overburden	0 - 20	Sandy till
Salisbury Fm.	20 - 250	Sandstones, claystones, and conglomerate

BOREHOLE NO. 2

DRILLED BY: Geological Survey of Canada YEAR: 1961

LOCATION: 46°05'30" N ; 64°45'20" W

ELEVATION: 7 ft. (a.s.l.)

Group/Formation	Depth Interval (ft.)	Description
Overburden	0 - 36	Brownish red clay
Salisbury Fm.	36 - 195	Sandstones and claystones

BOREHOLE NO. 3

DRILLED BY: Maritime Oilfields Ltd. YEAR: 1908

LOCATION: 46°06'05" N ; 64°43'50" W

ELEVATION: 50 ft. (a.s.l.)

Group/Formation	Depth Interval (ft.)	Description
Overburden	1 - 25	- - - - - - - - - -
Salisbury Fm.	25 - 550	Shale, sandstone, and conglomerate
Boss Point Fm.	550 - 685	Quartzose sandstone and shale
Hopewell Gp.	685 - 1220	Conglomerate, sandstone; minor limestone

BOREHOLE NO. 4

DRILLED BY: New Brunswick Gas and Oilfields Ltd. YEAR: 1918

LOCATION: 46°00'17" N ; 64°42'29" W

ELEVATION: 173 ft. (a.s.l.)

Group/Formation	Depth Interval (ft.)	Description
Overburden	0 - 18	- - - - - - - - - -
Boss Point Fm.	18 - 135	Quartz-pebble conglomerate, quartzose sandstone; minor shale
Hopewell Gp.	135 - 403	Grit, shale; minor limestone
Albert Fm.	403 - 1048	Grey shale, sandstone, and grit
Memramcook Fm.	1048 - 1297	Red shale and sandstone

BOREHOLE NO. 5

DRILLED BY: New Brunswick Gas and Oilfields Ltd. YEAR: 1919

LOCATION: 46°03'05" N ; 64°44'00" W

ELEVATION: 68 ft. (a.s.l.)

Group/Formation	Depth Interval (ft.)	Description
Overburden	0 - 15	- - - - - - - - - -
Boss Point Fm.	15 - 245	Quartzose sandstone; minor grit and shale
Hopewell Gp.	245 - 350	Shale; minor limestone and sandstone
Basement Complex	350 - 2860	Red granite and chlorite schist

BOREHOLE NO. 6

DRILLED BY: New Brunswick Gas and Oilfields Ltd. YEAR: 1931

LOCATION: 46°01'41" N ; 64°42'52" W

ELEVATION: 114 ft. (a.s.l.)

Group/Formation	Depth Interval (ft.)	Description
Salisbury Fm.	0 - 120	Red claystone and siltstone; green sandstone
Boss Point Fm.	120 - 243	Quartzose sandstone; quartz-pebble conglomerate; minor claystone, grit, and limestone
Hopewell Gp.	243 - 355	Red conglomerate and sandstone
Basement Complex	355 - 758	Granite and chlorite schist

BOREHOLE NO. 7

DRILLED BY: Killarney Oil and Gas Development Company Ltd. YEAR: 1970

LOCATION: 46°01'05" N ; 64°45'07" W

ELEVATION: 820 ft. (a.s.l.)

Group/Formation	Depth Interval (ft.)	Description
Overburden	0 - 12	- - - - - - - - - -
Petitcodiac and Hopewell groups	12 - 393.5	Grey and red shale, siltstone and sandstone; minor conglomerate
Basement Complex	393.5 - 412	Saprolite
	412 - 1000	Gabbro

BOREHOLE NO. 8

DRILLED BY: Killarney Oil and Gas Development Company Ltd. YEAR: 1970

LOCATION: 46°01'11" N ; 64°45'07" W

ELEVATION: 820 ft. (a.s.l.)

Group/Formation	Depth Interval (ft.)	Description
Overburden	0 - 10	- - - - - - - - - -
Petitcodiac and Hopewell groups	10 - 395	Red and grey shale, siltstone and sandstone; minor conglomerate
Basement Complex	395 - 411	Saprolite
	411 - 1018	Gabbro

BOREHOLE NO. 9

DRILLED BY: Killarney Oil and Gas Development Company Ltd. YEAR: 1970

LOCATION: 45°01'08" N ; 64°45'16" W

ELEVATION: 870 ft. (a.s.l.)

Group/Formation	Depth Interval (ft.)	Description
Overburden	0 - 16.5	- - - - - - - - - -
Petitcodiac and Hopewell groups	16.5 - 408.5	Red and grey shale, siltstone, and sandstone; minor conglomerate
Basement Complex	408.5 - 450	Saprolite
	450 - 527	Gabbro and gabbro pegmatite

BOREHOLE NO. 10

DRILLED BY: Killarney Oil and Gas Development Company Ltd. YEAR: 1970

LOCATION: 46°01'16" N ; 64°45'08" W

ELEVATION: 820 ft. (a.s.l.)

Group/Formation	Depth Interval (ft.)	Description
Overburden	0 - 12	- - - - - - - - - -
Petitcodiac and Hopewell groups	12 - 388.5	Red and grey sandstone and conglomerate; minor siltstone and shale
Basement Complex	388.5 - 400	Saprolite
	400 - 407	Ferruginous and bleached sandstone and minor shale
	407 - 422	Saprolite
	422 - 600	Gabbro